DSTO AUSTRALIA

ELECTRONICS RESEARCH LABORATORY

Communications Division

REPORT
ERL-0596-RE

METEOR BURST COMMUNICATIONS SYSTEM TRIAL 1990/91

by

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SUMMARY

This report describes a series of three Meteor Burst Communication (MBC) trials conducted over the eastern and northern regions of the Australian continent during 1990/91, using commercially available MBC equipment. Also included in the report is a comparison between the performances of the commercial equipment and an MBC system developed at DSTO Salisbury and trialled during 1989 and 1990.

JUN 92

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FIGURES (Cont)

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FIGURES

ABBREVIATIONS

DSTO	Defence Science and Technology Organisation
RAAF	Royal Australian Air Force
MBC	Meteor Burst Communications
MCC	Meteor Communications Company
UTC	Universal Coordinated Time

1 INTRODUCTION

A meteor burst communications link was tried over two paths, at 34^{o} and 17^{o} latitude respectively, using commercial equipment loaned to the DSTO by the RAAF. The purpose of these trials was to check and record the performance of the equipment, especially when operating in the northern region of Australia, and to compare the results with those of previous trials conducted on DSTO equipment in 1990 [1].

The equipment on test was manufactured by Meteor Communications Company of Kent, Washington, USA. It comprised the following items

- MCC-520 master station
- MCC-540B remote communications terminal
- Two five-element yagi antennas.

The MCC-520 master station incorporated a 500 W transmitter while the MCC-540B remote communications terminal incorporated a 300 W transmitter. Both sites used five-element yagi antennas. The frequencies used were in the 43 to 44 MHz band. As the remote terminal was designed to operate only intermittently from a battery supply, an auxiliary mains-powered charger was used to ensure that the battery would hold up under the maximum throughput conditions required for the trial. Binary phase shift keyed modulation at 4800 bits/s was used. The operating mode employed was half duplex.

Messages were composed using the seven bit ASCII character set. The equipment is designed to accept a plain text ASCII message and route it to another terminal in a network. In the case of these DSTO trials, there was only one other terminal available (the remote terminal), but the protocol still required a routing address to be given. If a message sent from the remote terminal carries its own destination address then it would be first passed to the master and then relayed back to the remote terminal.

For the trial, a Hewlett-Packard 9000 computer was connected to the remote terminal and programmed to send enough 'self addressed' messages of fixed length to the terminal to keep its buffer at least half full, thereby simulating saturated traffic flow conditions. The number of messages passing every hour was counted and logged. Some of the computer-generated messages were designated 'high priority' to enable measurement of the average time, (waiting time) taken for these messages to be sent on the 'round trip' via the master terminal.

The MCC-520 master station used an IBM PC as a message entry device. For the DSTO trial, the PC was programmed to record both the message rate and the background rf noise level; the latter to check for interfering signals.

2 TRIAL CONFIGURATION

2.1 Trial 1

For this trial the master terminal was positioned at Salisbury, South Australia and the remote terminal at Richmond Air Force Base, NSW. This is an east-west path of 1120 km on a mean latitude of 34^{o} south. It is almost the same as the path used for the 1990 DSTO trial from Salisbury to Jervis Bay [1]. The installation at Salisbury used a 14 m high antenna while the Richmond installation employed an 18 m high antenna. Data were recorded continuously over the period from 12 July to 26 September 1990, except for a break from 1 - 19 September when a failure occurred in the remote transmitter.

2.2 Trial 2

For this trial the master terminal was positioned at the Darwin Air Force Base, NT., (latitude 12.5^{o} south), while the remote terminal was positioned at the Curtin Air Force Base (near Derby) in WA, (latitude 17^{o} south). The path distance was 950 km. The Darwin installation used an 18 m high antenna while the Curtin installation used a 10 m high mast. Data were recorded continuously from 20 October to 1 November 1990, whereupon the trial was suspended and both stations dismantled to protect the equipment from the possibility of lightning damage during the tropical wet season.

2.3 Trial 3

In June 1991, following the passing of the wet season, the equipment was reinstalled at the Darwin and Curtin Bases and the trial recommenced. For this trial the antenna at Curtin was mounted on an 18 m high mast and placed at a different location on the Base. In all other respects the configuration was the same as that used for Trial 2.

3 SUMMARY OF RESULTS

3.1 Trial 1

As expected, during this trial the number of complete 200-character messages passing every hour varied over a 4:1 range from (6 to 26) during the day. During the first week, the average count was 14.5 messages/h, ie. 47 characters/min. During the latter period of the trial, from 21 August to 26 September, the average count fell to 10.3 messages/h. This equates to a mean throughput of 36 characters/min.

Figure 1 below shows the average message throughput for the first ten days of the trial, ie. from 11-22 July. Each day is divided into half hourly segments and the recorded message counts are averaged for each period of the daily cycle. The baseline is Central Australian Standard Time (which is nine and a half hours ahead of UTC).

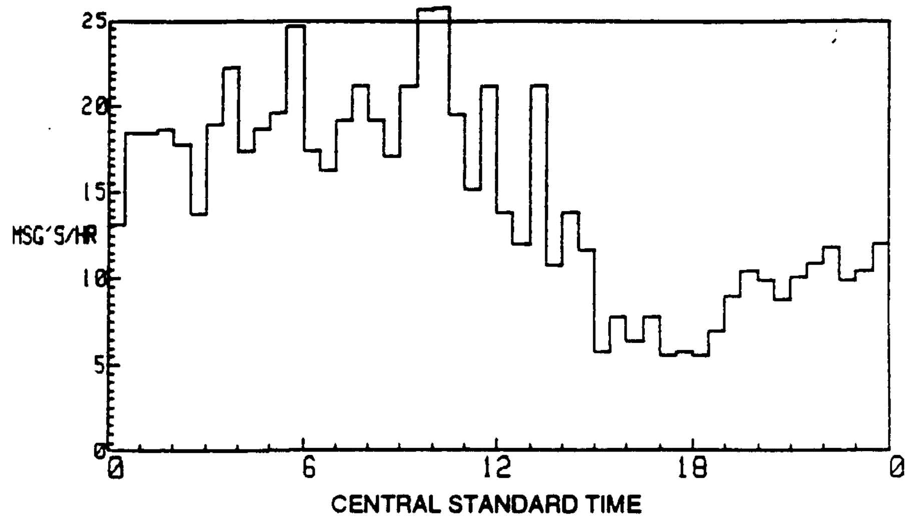

Figure 1 **Average Message Throughput - Salisbury to Richmond 11-22 July 1990 - Trial 1**

Figure 2 below shows the average message throughput for Trial 1 for twelve days between 21 August and 26 September. From 26 September, the results were logged and averaged at hourly intervals. The generally lower daily throughput over the September period is consistent with previous experience of seasonal variation (ref. 1 pages 13, 14, 15 of part 5).

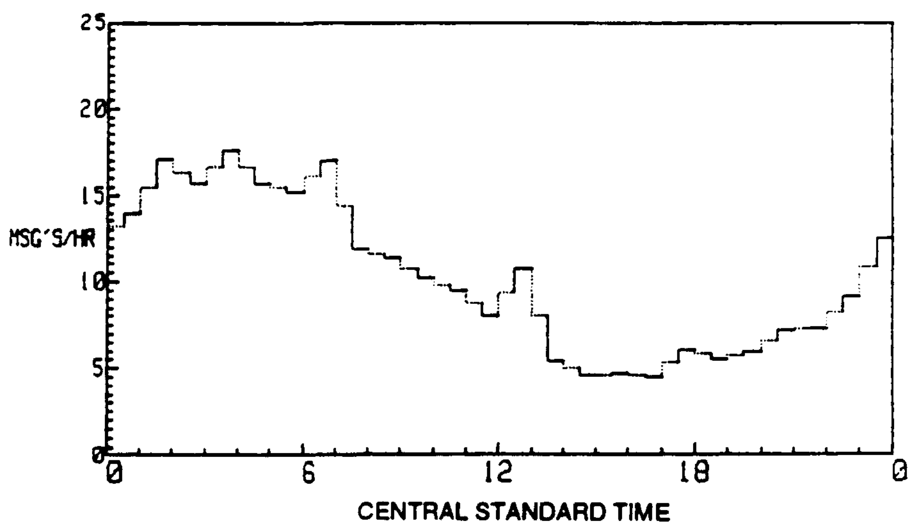

Figure 2 **Average Message Throughput - Salisbury to Richmond 21 August to 26 September 1990 - Trial 1**

The average waiting time of the 200-character messages for the twelve day period is shown in Figure 3. As can be seen from the figure, the waiting time varied over a daily cycle, from a minimum of 450 s to a maximum of 1300 s. The average overall waiting time was 780 s (13 min). Note that the waiting time is the total time taken for the message to pass both ways across the link. Waiting time thus represents the situation in a star network where messages may be sent from one remote terminal to another via an intermediate node (the master station). The waiting time for messages to pass one way only may be assumed to be half of that above.

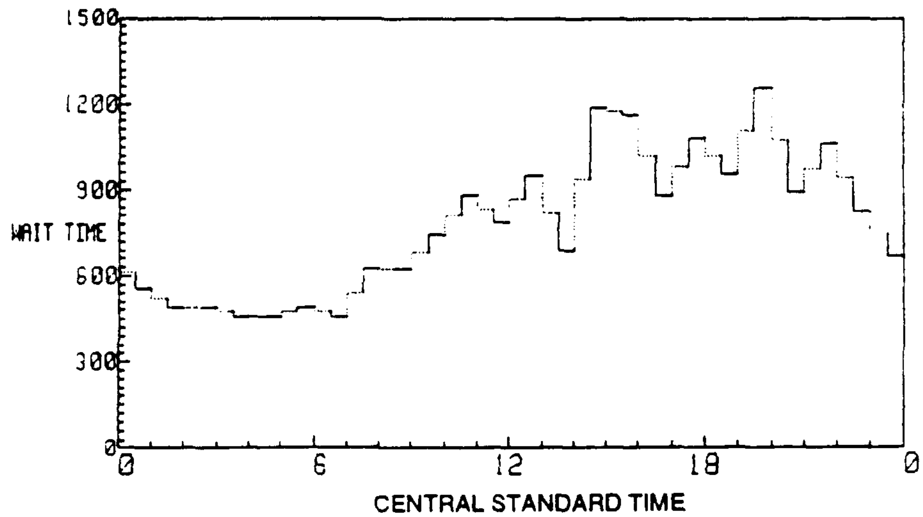

Figure 3 **Average Message Waiting Time - Salisbury to Richmond 21 August to 26 September 1990 - Trial 1, 200 character message**

Figures 4 and 5 below show the hourly averages of the number of message synch acquisitions during the two periods of 11 - 21 July and 21 August to 26 September respectively. Note that the average is higher for the July period.

The parameter was read from the status report every hour and although the exact meaning of the measurement is vague, as it is not known how many sync acquisitions actually occur at each meteor burst, it does give an indication of the level of meteor activity.

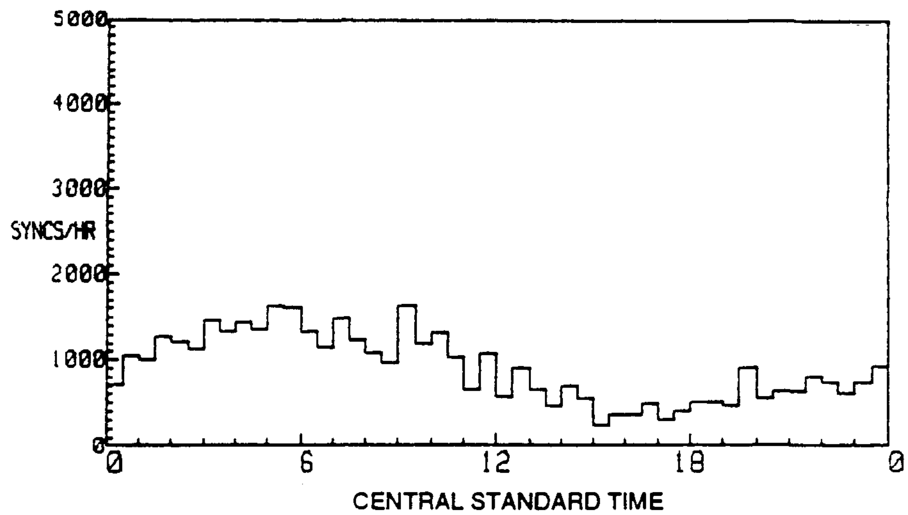

Figure 4 Average Message Synchs per Hour - Salisbury to Richmond 11-22 July 1990 - Trial 1, 200 character message

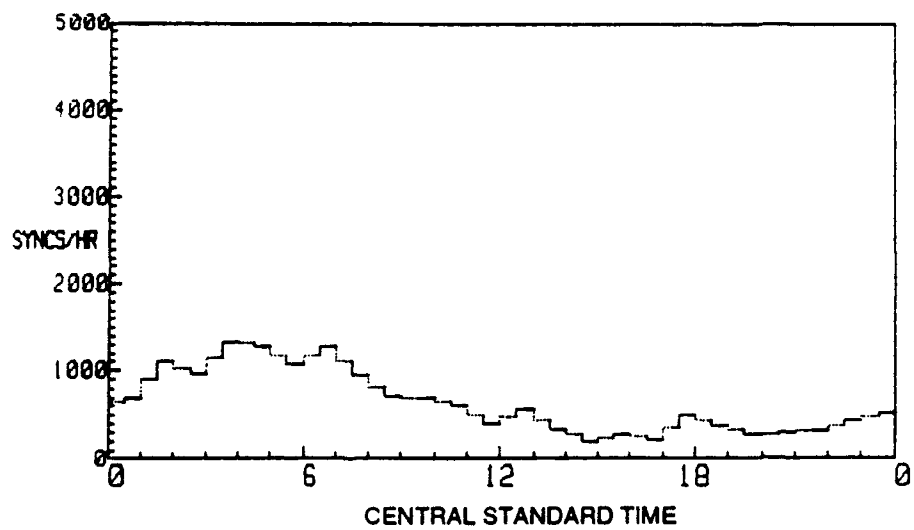

Figure 5 Average Message Synchs per Hour - Salisbury to Richmond 21 August - 26 September 1990 - Trial 1, 200 character message

During the period 14 - 20 August the average message length was reduced to 50 characters. Under these conditions the hourly flow of traffic varied from 11 to 43 messages/h, with an average of 26.4. This was equivalent to a mean throughput of 21 characters/min. The waiting time improved, varying from 200 to 850 s. This averaged to 508 s or 8.46 min over the period. These results are shown in Figures 6 and 7 below.

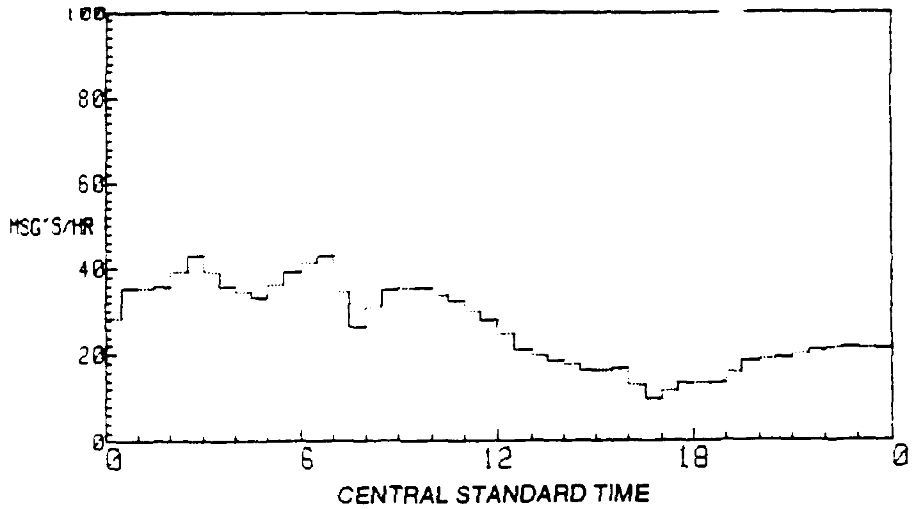

Figure 6 Messages Rate per Hour - Salisbury to Richmond 14 - 20 August 1990 - Trial 1 for 50 character messages

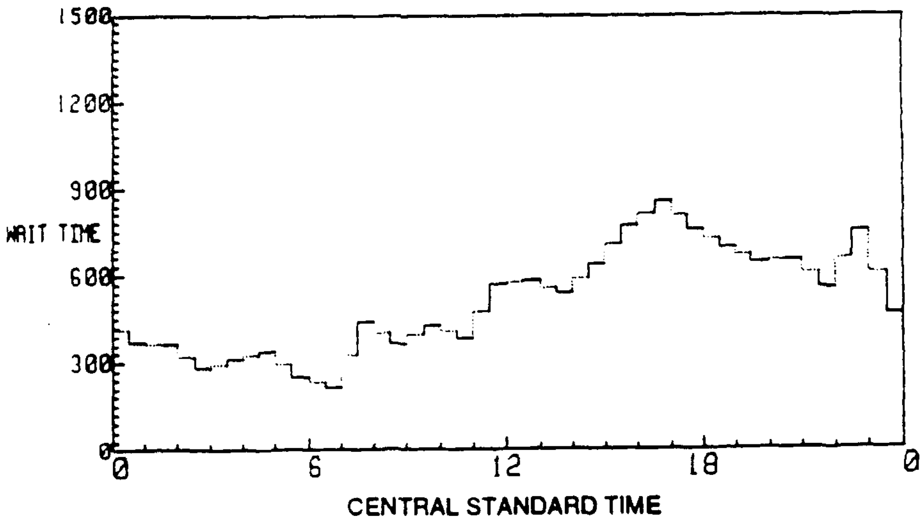

Figure 7 Average Message Waiting Time - Salisbury to Richmond 14 - 20 August 1990. Trial 1 for 50 character messages

3.2 Trial 2

Logging of the message traffic between the Darwin and Curtin Air Force Bases began on 20 October and continued without a break until 8 November. Only 200-character messages were used. Figure 8 below shows the average daily rate of throughput. Although the messages were counted on an hourly basis, the computer plotted interpolations on the half hour. Note that the baseline in Figure 8 is in Central Standard Time, and approximately one hour ahead of local time in this case. The average for the period was 10.9 messages/h (36 characters/min). Which is similar to the latter period of Trial 1 (see Figure 2). The average waiting time, as plotted in Figure 9, is better, however, being 563 s compared with 780 s for Trial 1 (see Figure 3).

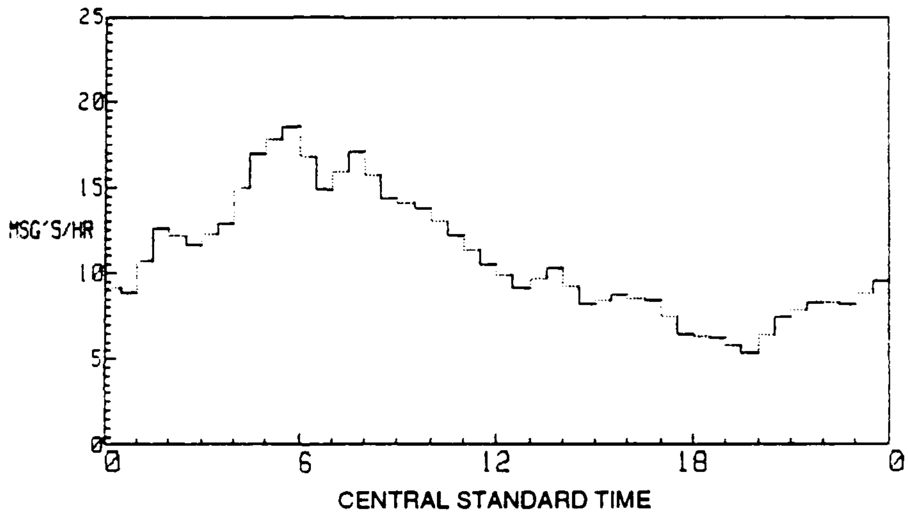

Figure 8 **Average Message Throughput - Darwin to Curtin 21 October to 8 November 1990 - Trial 2**

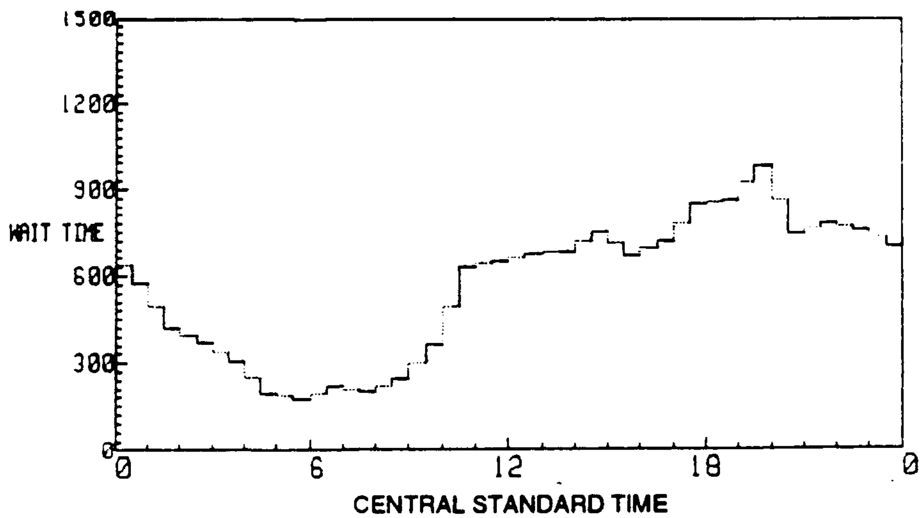

Figure 9 **Average Message Waiting Time - Darwin to Curtin 21 October to 8 November 1990 - Trial 2**

Figure 10 below shows the average synch acquisitions per hour during the period of the second Trial. Comparing this figure with Figures 4 and 5 shows a marked increase (more than double) over that of the Salisbury to Richmond path. A similar comparison of Figures 2 and 8, however, shows that the Average Message Throughput showed only a marginal improvement. Subsequent examination of the hourly status reports revealed that the reason for this could be attributed to a condition defined on the report as "TX LIMITED" in which the remote terminal transmitter automatically 'shut down' whenever there were more than 500 unacknowledged transmissions counted in any one hour.

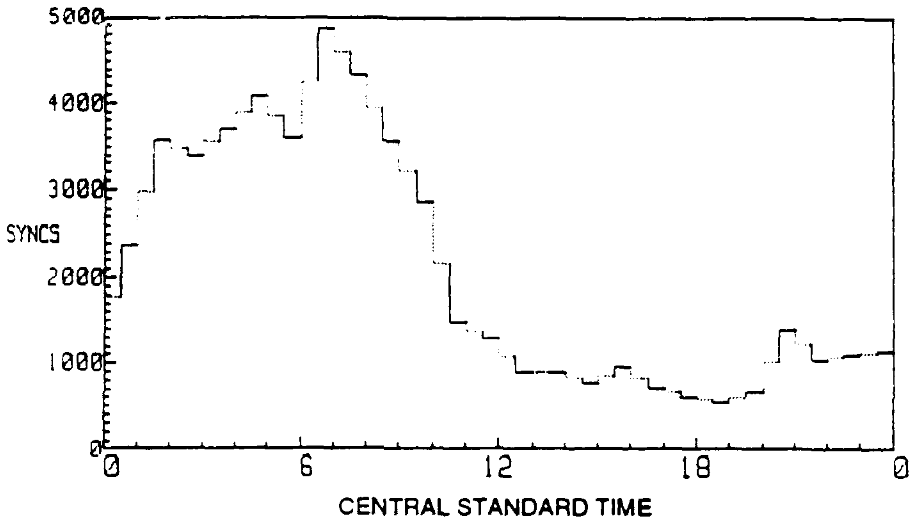

Figure 10 **Average Message Synchs per Hour - Darwin to Curtin 21 October to 8 November 1990 - Trial 2**

3.3 Trial 3

Logging of the message traffic between Darwin and Curtin recommenced on 25 June and continued until 11 July, when a serious hardware failure in the remote terminal transmitter brought an early end to the trial.

The rate of synchs per hour recorded during the period of the trial is plotted in Figure 11. A higher than usual meteor activity was observed during the afternoon periods. The peak is 9400 syncs but the scale of the graph is the same as Figure 10 for comparison. This is in line with previous experience [1], when it was found that the months of June and July have periods of high meteor shower activity.

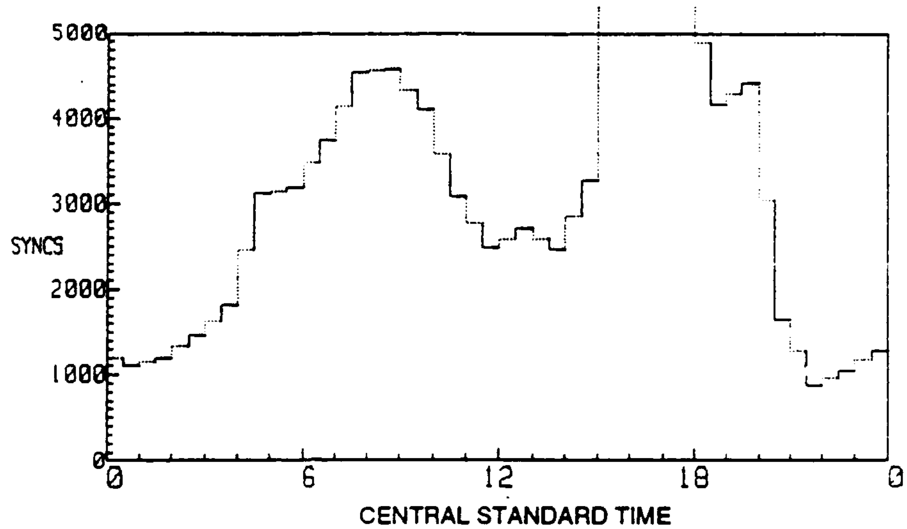

Figure 11 **Average Message Synchs per Hour - Darwin to Curtin June 25 to July 11 1991 - Trial 3**

The average message throughput for Trial 3 is plotted in Figure 12 below. As is the case with Figure 11, these results also show a higher than usual throughput level in the afternoons. The daily average was 16.3 messages/h which equates to an average of 54 characters/min.

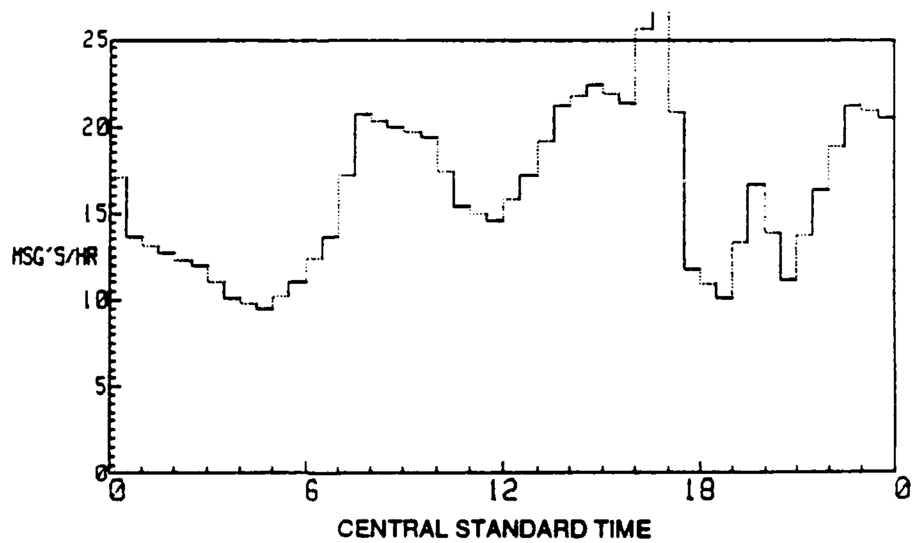

Figure 12 **Average Message Throughput - Darwin to Curtin June 25 to July 11 1991 - Trial 3**

Whilst the message counts during the morning periods were high, they were much less than expected. This was again due to the "TX LIMITED" phenomenon referred to in paragraph 3.2. The log showed that this condition had been occurring repeatedly from approximately 3 a.m. to noon every day. The measured waiting time was not affected, however. Figure 13 indicates a mean message waiting time of 428 s for a message to travel each way.

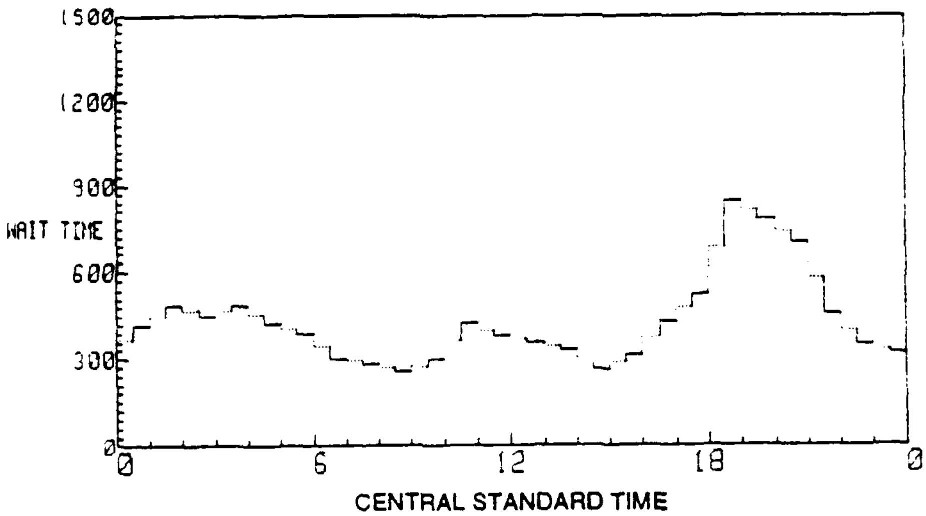

Figure 13 **Average Message Waiting Time - Darwin to Curtin 25 June to 11 July 1991 - Trial 3**

3.4 General Observations

The recorded noise level at Darwin was consistently very low indicating no appreciable interference at that site. The noise level at the Curtin RAAF Base, although checked on one day only, was also low.

While the master station was operating at DSTO Salisbury, it was found to be emitting broadband pulses in the lower VHF spectrum. Whilst this caused no problems during the trials, it would be a matter of concern if the equipment were to be co-sited with other VHF radio receivers. The problem was traced to key clicks caused by the cyclic switching of the transmitter when being used in the half duplex mode.

In addition to the data recorded at the remote terminal for each trial, the number of messages received by the master station each hour was also recorded. This value is shown plotted in Figure 14 for the whole period of each of the first two trials (200-character messages only). Note that there is a local time skew of about one hour between the two locations, as both are plotted against Australian Central Standard Time.

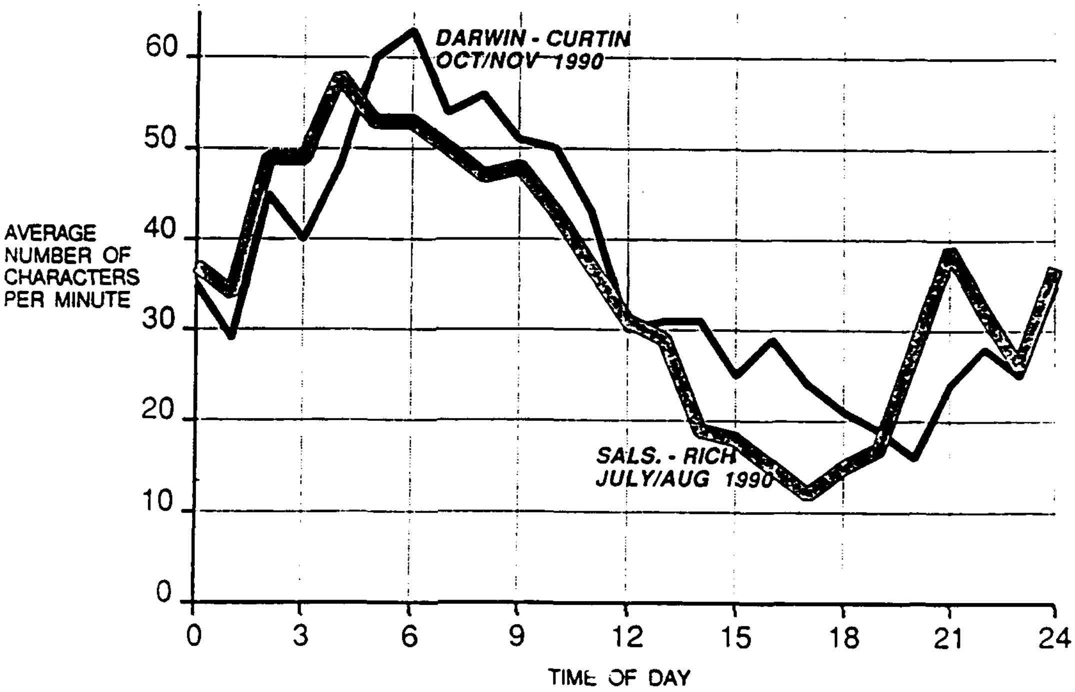

Figure 14 **Average daily message throughput - Salisbury/Richmond, July/August 1990 and Darwin/Curtin, October/November 1990**

Figure 15 below provides a comparison of the message throughputs of Trials 2 and 3 (same location, Darwin-Curtin, but four months apart). The drop in throughput during the mornings, due to the "TX LIMITED" phenomenon and the increase in meteor shower activity in the afternoon periods is again evident.

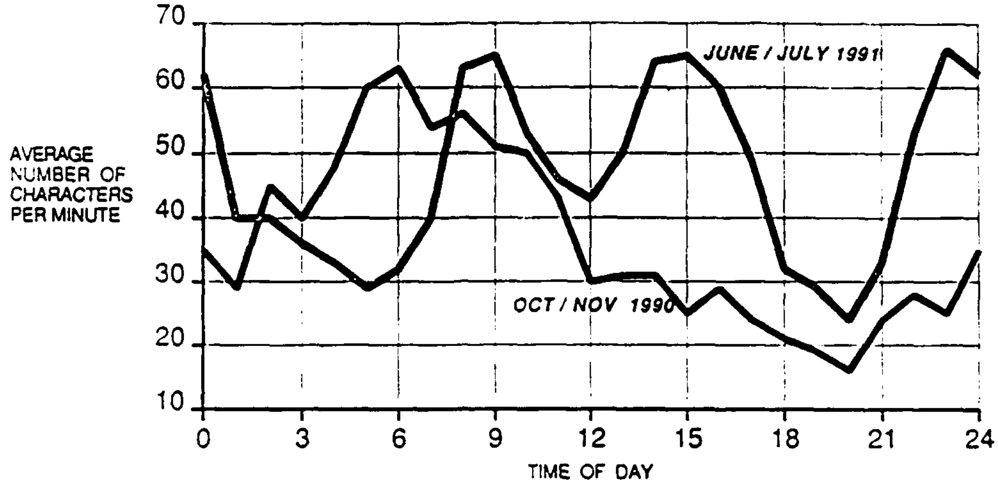

Figure 15 **Message throughput comparison - Darwin to Curtin for the periods October/November 1990 and June/July 1991**

To enable a comparison to be made between the measurements made during the 1989 Salisbury to Jervis Bay Trial and that of the 1990 Salisbury to Richmond Trial (Trial 1) the average message throughputs of both trials are shown plotted in Figure 16 below.

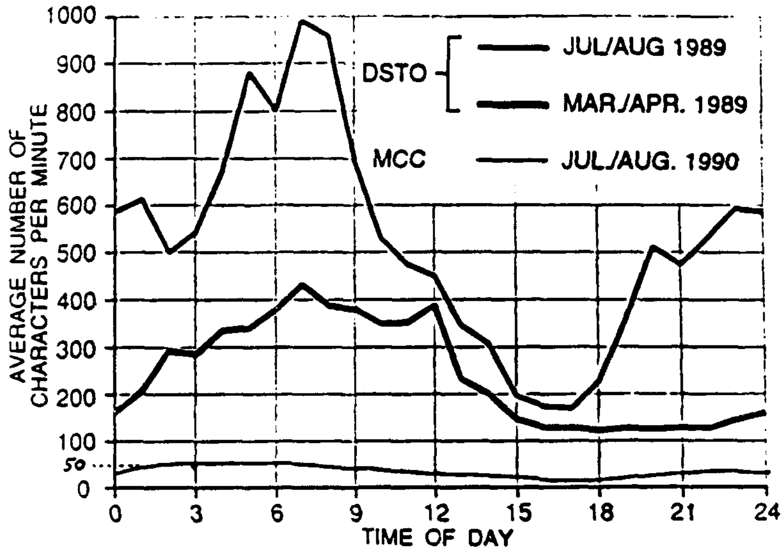

Figure 16 **Comparison of average message throughput 1989 Salisbury/Jervis Bay and 1990 Salisbury/Richmond trials**

4 CONCLUSIONS

The MCC system, as supplied, demonstrated that reliable, low cost, over-the-horizon, message (or low rate data) communications is possible in the northern regions of Australia using meteor trail propagation.

This particular equipment is not suited to measuring the full capacity of meteor trail propagation over a single point to point link. This is because the remote terminal cannot operate in full duplex mode and self limits its transmitter duty cycle to about 10 percent. The combination of these factors means it cannot make use of the shorter length bursts and it has reduced efficiency on the longer ones.

The measured average throughput rate of between 40 and 50 characters/min was lower then expected. In comparison, the Jervis Bay to Salisbury trial of 1988/89, (which was operated over a similar path) provided a much higher throughput, in the order of 500 characters/min. However, the DSTO equipment used for that trial was a full duplex system and had no networking overheads, thus the minimum usable burst length was less, enabling shorter trails to be exploited. This is highlighted by Dickson and Cannon [2]. Conversely, the rate of undetected character errors in the MCC system, although not recorded, appeared to be much better than in the DSTO system; this again is a trade-off against throughput.

The low throughput when using a message length of only 50 characters may be due to the higher proportion of protocol overhead compared with such short messages. A message length greater than 200 characters was not tried.

It was not possible to discern the difference between the data rates obtained at the two locations, purely as a function of latitude, considering that a 30% change in the data rate occurred even during the two months course of Trial 1, the same time span as separated the first two trials. The much higher rates which occurred in Trial 3 were probably caused by the occasion of a favourable meteor shower. The meteor activity was then so high as to cause the remote terminal transmitter to self limit its transmissions. Had this not been so it would have provided a much higher data throughput measurement.

5 ACKNOWLEDGEMENTS

The assistance of the RAAF in providing the commercial equipment for three trials, together with the necessary travel funds and technical assistance is gratefully acknowledged.

6 REFERENCES

1. John A. Hackworth — "Meteor Burst Communications Study", ERL-0519-RE. July 1990.

2. A. Dickson and P. Cannon — "The Impact of the Propagation Medium on the OSI Model in HF Communication Systems", TTCP Proceedings of Panel STP-8, Subgroup S, May 1990.

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16. Abstract

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